PHLOEM LOADING AND UNLOADING

As mentioned earlier, translocation of organic solutes such as sucrose (i.e., photosynthates) takes place through sieve tube elements of phloem from **supply end** (or **source**) to **consumption end** (or **sink**). But, before this translocation of sugars could proceed, the soluble sugars must be transferred from mesophyll cells to sieve tube elements of the respective leaves. This transfer of sugars (photosynthates) from mesophyll cells to sieve tube elements in the leaf is called as **phloem loading**. On the other hand, the transfer of sugars (photosynthates) from sieve tube elements to the receiver cells of consumption end (i.e., sink organs) is called as **phloem unloading**. Both are energy requiring processes.

PHLOEM LOADING

As a result of photosynthesis, the sugars such as sucrose produced in mesophyll cells move to the **sieve tubes** of **smallest veins** of the leaf either directly or through only **2-3 cells** depending upon the leaf anatomy. Consequently, the concentration of sugars **increases in sieve tubes** in comparison to the surrounding mesophyll cells.

The movement of sugars from mesophyll cells to sieve tubes of phloem may occur either through **symplast** (*i.e.*, cell to cell through plasmodesmata, remaining in the cytoplasm) or the sugars may enter the **apoplast** (i.e., cell walls outside the protoplasts) **at some point** en route to phloem sieve tubes. In the latter case, the sugars are actively loaded from apoplast to

sieve tubes by an **energy driven transport** located in the plasmamembrane of these cells. The mechanism of pholem loading in such case has been called as **sucrose –H⁺ symport** or **cotransport mechanism**. According to this mechanism (Fig. 15.5) protons (H^+) are pumped out through the plasmamembrane using the energy from ATP and an ATPase carrier enzyme, so that concentration of H^+ becomes higher outside (in the apoplast) than inside the cell. Spontaneous tendency toward equilibrium causes protons to diffuse back into the cytoplasm through plasmamembrane coupled with transport of sucrose from apoplast to cytoplasm through **sucrose –H⁺ symporter** located in the plasmamembrane.

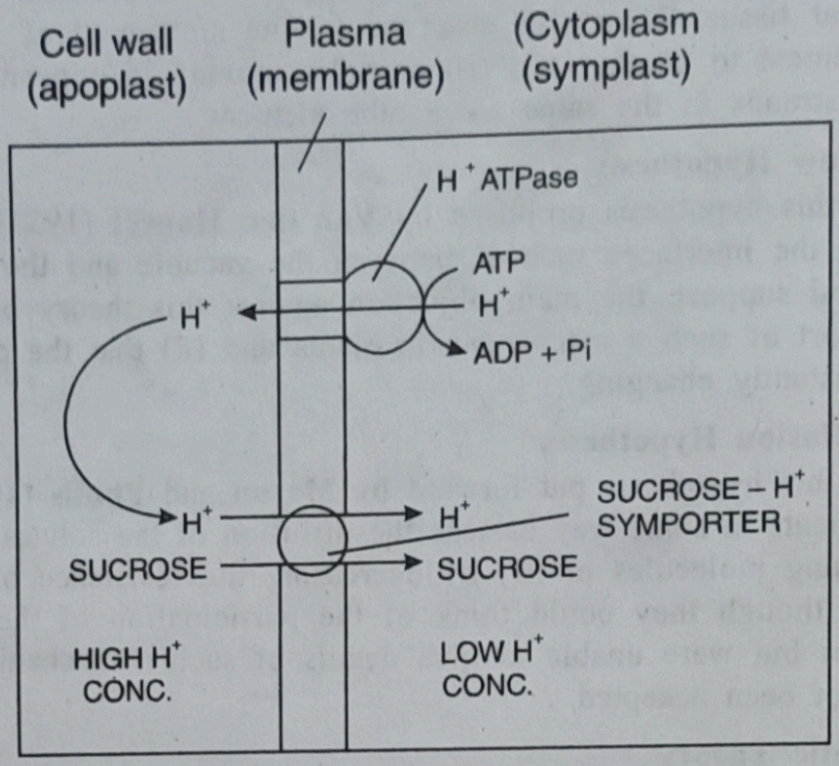

Fig. 15.5. Sucrose –H^+ symport or cotransport mechanism.

The mechanism of the transfer of sugars (sucrose) from mesophyll cells to apoplast is however, not known.

Phloem loading is specific and selective for transport sugars.

Both symplastic and apoplastic pathways of phloem loading are used in plants but in different species. In some species however, phloem loading may occur through both the pathways in the same sieve tube element or in different sieve tube elements of the same vein or in sieve tubes in veins of different sizes.

Experimental findings have revealed certain patterns in apoplastic and symplastic loading of sugars in phloem (Table 15.1), which appears to be related with the type of sugar transported to phloem, type of companion cells (ordinary, transfer or intermediary) and number of plasmodesmata (few or abundant) connecting the sieve tubes (including the companion cells) to surrounding cells in smaller veins.

Table 15.1 Patterns in apoplastic and symplastic phloem loading.

	Apoplastic loading	**Symplastic loading**
Type of sugar transported	Sucrose	Sucrose + other oligosaccharides
Type of companion cells in the small veins	Ordinary or transfer cells	Intermediary cells
Number of plasmodesmata connecting the sieve tubes (including companion cells) to surrounding cells	Fewer	Abundant

(See glossary for explanation of different types of companion cells.

To some extent, phloem loading is also correlated with the family of plant, its habit (trees, shrubs, vines or herbs) and climate such as temperate, tropical or arid climate.

(After phloem loading, the sugars are translocated to consumption end or sink organs by mass flow as has been described earlier in this chapter).

PHLOEM UNLOADING

It occurs in the consumption end or sink organs (such as developing roots, tubers, reproductive structures etc.) Sugars move from sieve tubes to **receiver cells** in the sink involving following steps :

(*i*) **Sieve element unloading.** In this process, sugars (imported from the source) leave sieve elements of sink tissues.

(*ii*) **Short distance transport.** The sugars are now transported to cells in sink by a short distance pathway which has also been called as post-sieve element transport.

(*iii*) **Storage and metabolism.** Finally, sugars are stored or metabolized in the cells of the sink.

As with the phloem loading process, sucrose unloading also occurs through symplast via plasmodesmata or through apoplast at some point en route to sink cells.

Phloem unloading is typically **symplastic** in growing and respiring sinks such as meristems roots, and young leaves etc. in which sucrose can be rapidly metabolized. (Young leaves act as sink until their photosynthetic machinery is fully developed, at which point they become sources).

Usually, in storage organs such as fruits (grape, orange etc.), roots (sugar beet) and stems (sugarcane), sucrose unloading is known to occur through apoplast. However, according to **Oparka** (1986), phloem unloading in potato tubers from sieve elements to cortical cells is a symplastic passive process.

Because, there are wide varieties of sinks in plants which differ in structure and function, no one scheme of phloem unloading is available.